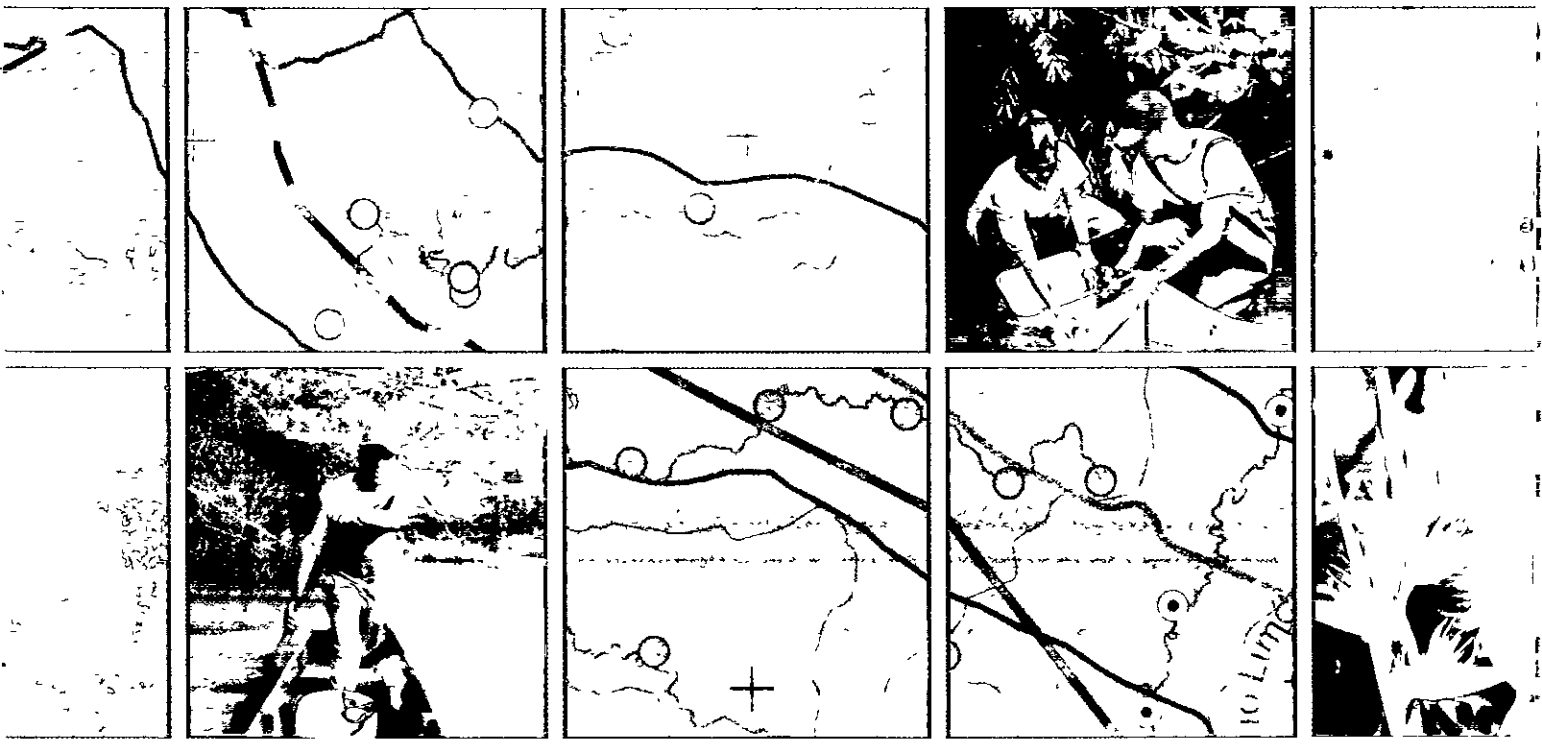
Panama Canal Watershed Monitoring Program - 2000

EXECUTIVE SUMMARY



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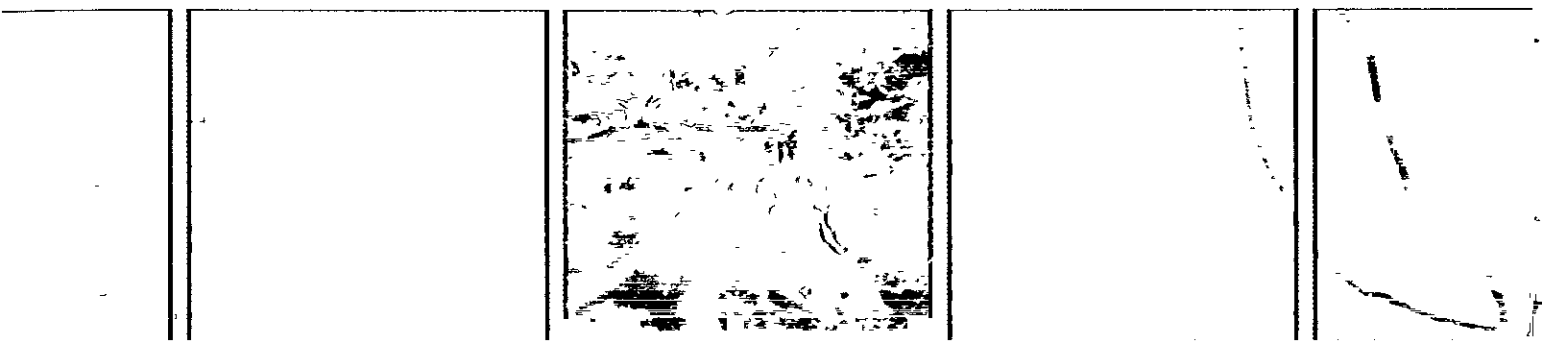

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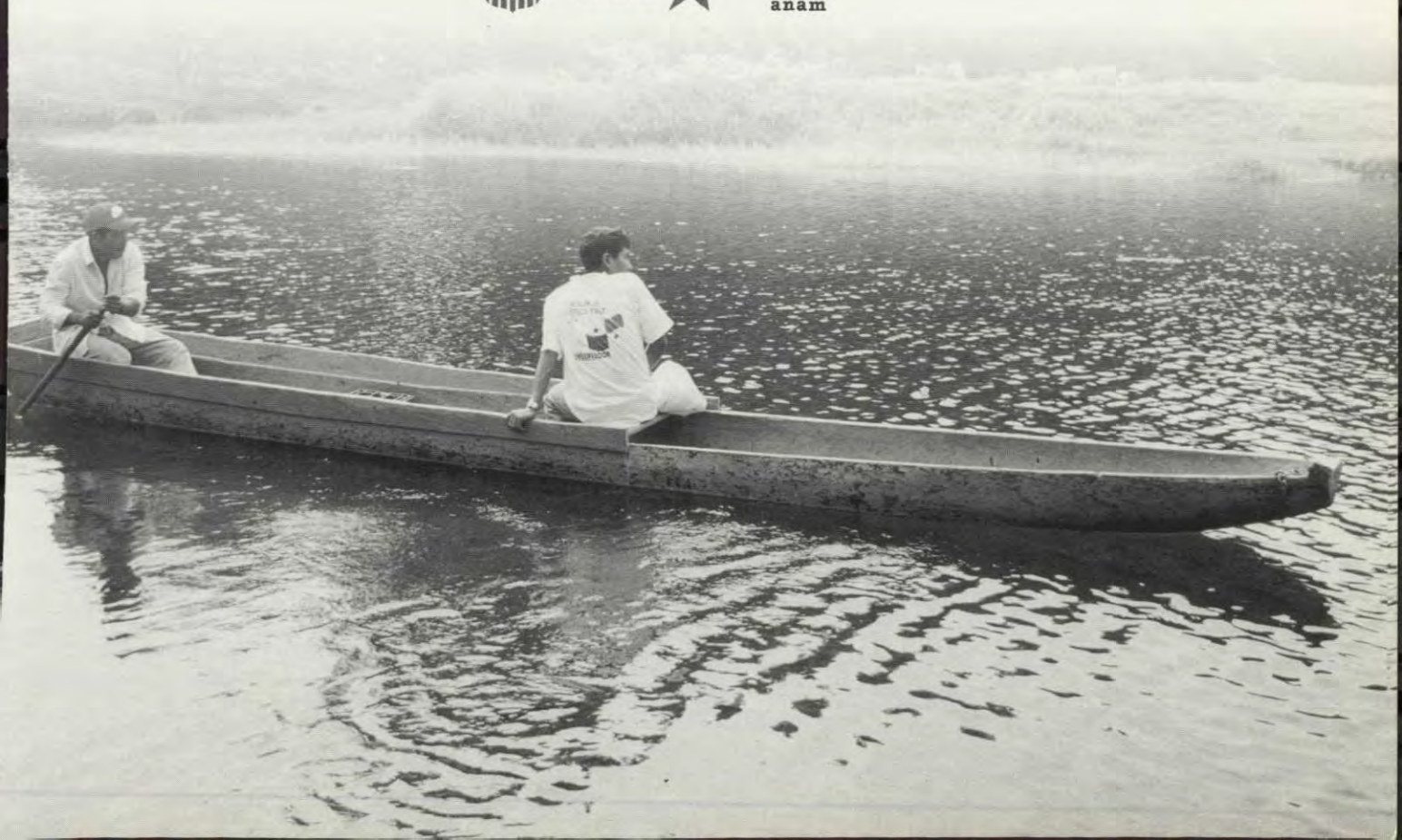

Panama Canal Watershed
Monitoring Program - 2000
Executive Summary

Edition:
Marcelo de la Rosa
Devin Reese

Graphic Desing:
Novo Art, S.A.

Cover photographs:
Autoridad Nacional del Ambiente
Jerry Bauer

The Louis Berger Group
Vía Argentina • El Cangrejo
Edificio Del Prado • 2-B
Panamá, Rep. de Panamá
Tel: (507) 265-4033
Fax: (507) 213-0544

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Introduction

Presented here, by component and in an integrated form, are the most relevant aspects and principal conclusions and recommendations resulting from the extensive work performed by the Panama Canal Watershed Monitoring Program (PMCC) 2000 under the administration of The Louis Berger Group, Inc. (LBG). In general, there has been conceptual continuity between the activities performed during the previous administration by the Smithsonian Tropical Research Institute (STRI) and those conducted during the present working period; some of the more ambitious sub-programs initiated during the STRI administration, were completed during the year 2000.

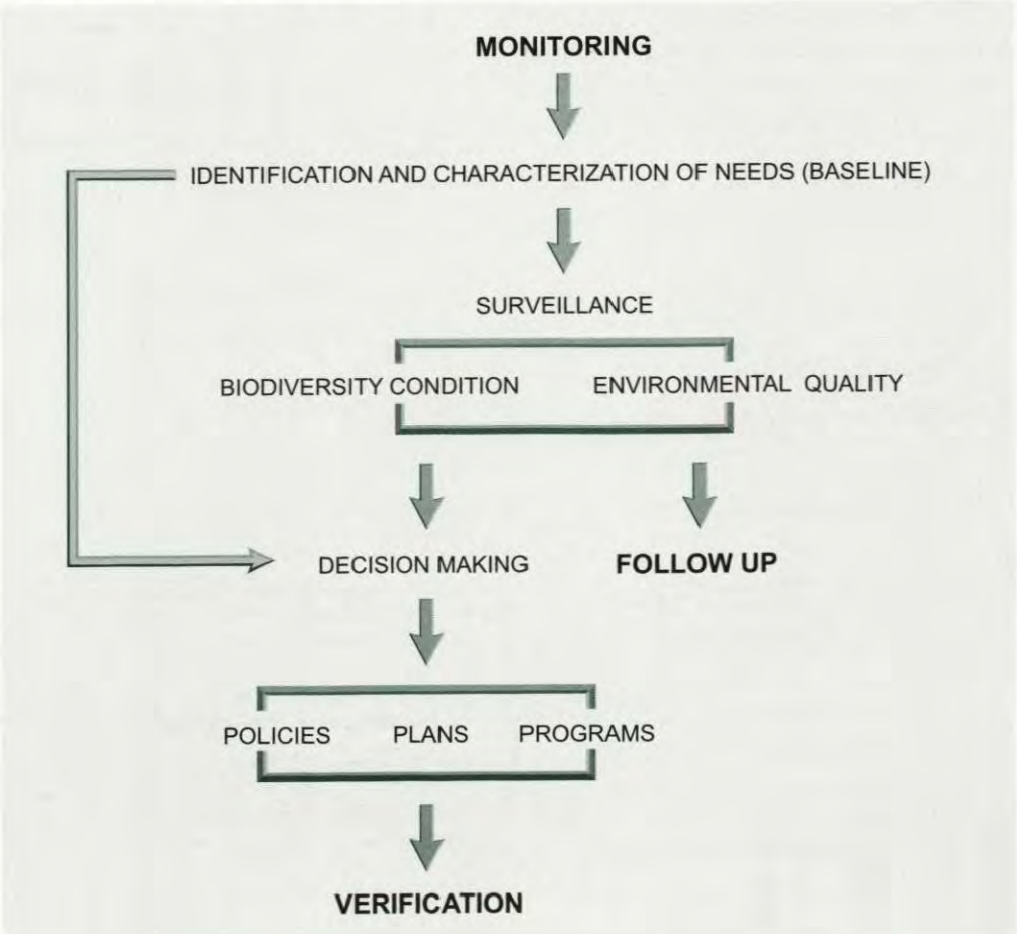
General

The Panama Canal Watershed Monitoring Program has constituted a sustained effort over four years during which, with financing from the United States Agency for International Development (USAID), has created the capacity to conduct scientifically rigorous and technically modern monitoring activities. The training of more than 40 people, the sophisticated equipment incorporated into the program, and the acquisition and development of specific methodologies have rendered this one of the most serious environmental efforts carried out in Panama. The Program finished, under USAID funding, at the end of January 2001. The environmental institutions of the country, the National Environmental Authority (ANAM) and the Panama Canal Authority (ACP), have incorporated (or are in the process of incorporating), the majority of the personnel trained during the development of the program and plan to use the acquired capabilities to conduct similar activities such that the objectives to institutionalize the Program can be considered met.

The concept of monitoring

As understood by the PMCC and thus applied, the concept of monitoring corresponds to the characteristics shown in Figure 1.

Figure 1. The monitoring concept.



Two clear lines of action arise from this concept:

- Environmental Health and Biodiversity Condition surveillance
- Follow-up on future actions to be taken in the watershed.

The implementation of the latter is still pending but the efforts of several institutions coordinated by the Inter-institutional Canal Watershed Commission (CICH) will soon produce results in that sense.

The Program's structure

The year 2000 program was structured with a holistic approach based on the development of indicators that serve to establish, in a quantitative, dynamic and expeditious way, the environmental health of the watershed and its principal threats.

Figure 2 shows the basic inputs and instruments used, which were complemented by other elements including the physical, chemical, and biological water quality assessment and other hydrological information.

The monitoring tools that were developed consist of three indicators:

- Index of Biological Integrity (IBI).
- Index of Physical Integrity (IFI).
- Human Intervention Analysis.

The concept of applying these indicators is not independent but integrated. The status indicators (IBI, IFI) signal the impacts on the environment and natural resources while the intervention analysis explains the causes. Plotting the status indicators against the intervention analysis yields a functional dependence (gradient); the evolution of this gradient over time is a precise radiography of the comprehensive environmental condition in the watershed as shown in Figure 3, developed for the IBI:

Figure 3. Human intervention and the cause-effect concept.

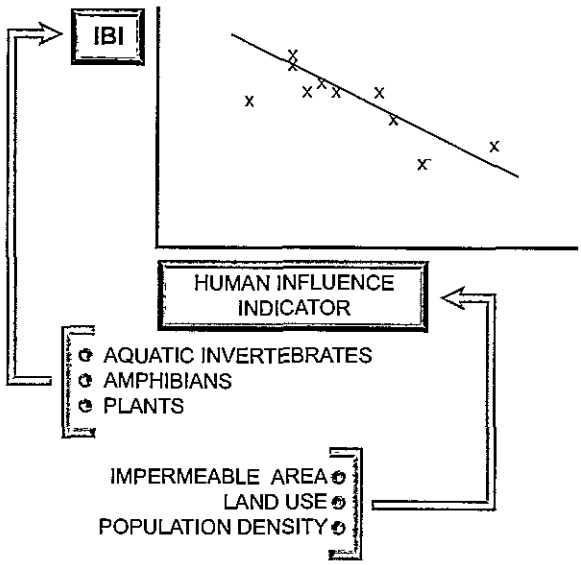
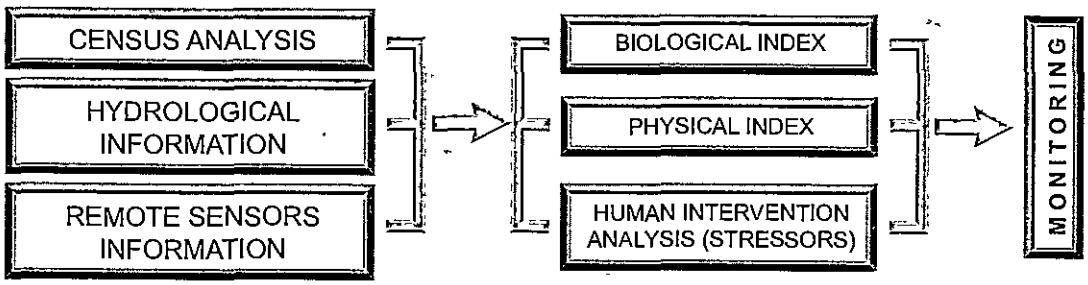


Figure 2. Monitoring inputs and indicators.



Description of the indicators

The components and functional relationships of the three indicators are described hereon. The attached flowcharts summarize the activities involved.

Index of Biological Integrity (IBI)

Definition

Biological integrity is the capacity to support and sustain a well-balanced community of individuals, having a species composition and a functional organization comparable to those of the natural habitat in the region. In order to evaluate the biological integrity, an index that examines a collection of biological attributes (metrics) known as Index of Biological Integrity (IBI), was used.

Figure 4 shows the IBI elements:

Objectives

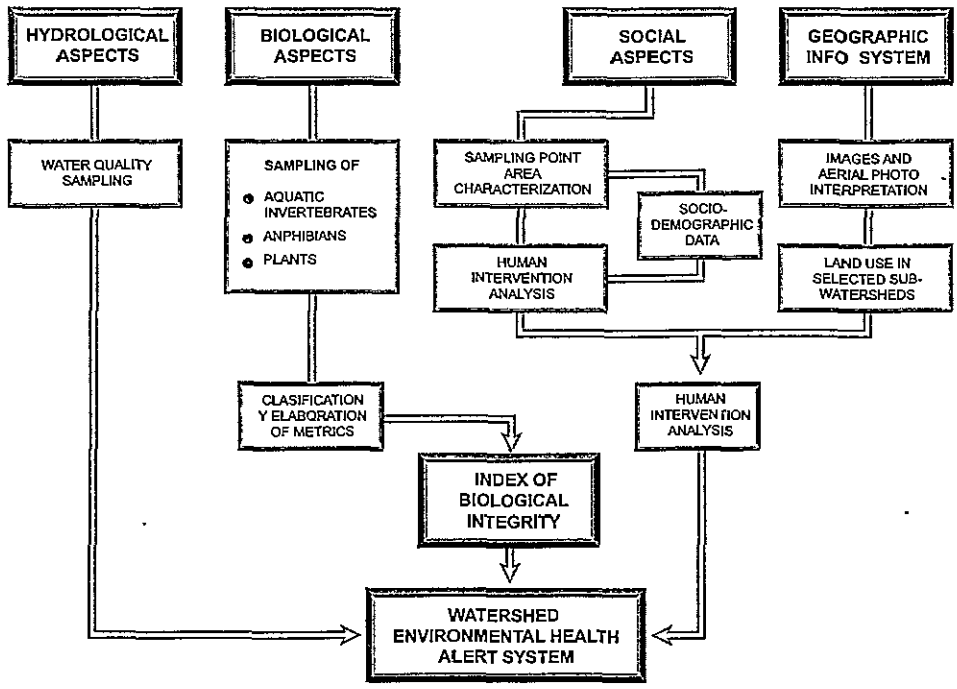
Determine the condition of aquatic and terrestrial environments, specifically in creeks and their margins (including the riparian strip where it is present) based on the concept of biological integrity.

Methodology

First, sites of interest in watersheds are selected along a gradient of human intervention with the help of GIS. In these sites, sampling of aquatic invertebrates, amphibians and plants was performed.

Aquatic invertebrate sampling was performed in the riffles, at the beginning of the rainy season (May); for each replicate, a Surber sampler was used to collect the samples from the river bottom substrate. In the laboratory, each sample was cleaned and the remaining organisms were then sorted into orders and classified.

Figure 4. Components and functional relationships in the IBI.



The amphibian sampling was performed along the shoreline of the creeks during the dry and rainy seasons. During the dry season (January through April), daily sampling was carried out; the method consisted of identifying and counting all the amphibians found during a person's walk along a 200 m (long) x 1 m (wide) x 2 m (high) transect. During the rainy season (May through December), night sampling was performed along the same transect (or a similar one). Additionally, the vocalizations of the frogs were recorded for 15 minutes at 4 sampling points, separated by 150 m each. Later on, the recordings were analyzed in the laboratory.

The plant sampling was performed perpendicular to the creeks using 200 m long x 20m wide transects, one on each side. Each transect was subdivided in twenty 20 m x 20 m plots. Inside each of the 20 m x 20 m plots, subsequent 5 m x 5 m and 1m x 1m sub-plots were defined. In each of these, the species and number of trees with DAP > 10 cm (diameter at chest level), shrubs and plants with DAP between 1 and 10 cm, and small plants were respectively recorded. For each type of plot, data regarding the location, identification, coverage and height of the different vegetation strata, as well as the percentage of light penetration and the basal area, were obtained.

Sampling sites

Twenty-three sites were selected and sampled in total corresponding to micro-watersheds with different degrees of alteration or human influence (selected over a gradient of intervention).

The sampling sites are shown in Table 1 for each group of organisms:

Table 1. Sampling sites.

Site	Aquatic invertebrates	Amphibians	Plants
Quebrada Aguas Claras		o	
Quebrada Ancha (Chilibre)		o	o
Quebrada Ancha (Gatuncillo)	o	o	o
Quebrada Grande		o	o
Quebrada La Cabima (Pto 4)	o	o	o
Quebrada Ñajú/Pedernal	o	o	o
Quebrada Sardinilla		o	
Quebrada Sonadora	o	o	o
Río Agua Salud (V2)	o	o	o
Río Agua Salud (V3)	o	o	
Río Aguas Claras	o	o	o
Río Azote Caballo		o	
Río Cabuya		o	
Río Caño Quebrado		o	o
Río Casaya	o	o	o
Río Chilibrillo		o	
Río Frijoles	o	o	o
Río Frijolita	o	o	o
Río Gatún (Pto 1)	o	o	o
Río Gatuncillo (Pto 1)	o	o	o
Río Limbo		o	
Río Pescado		o	
Río Syristes		o	o

In order to establish a relationship between the degree of human intervention in the targeted micro-watersheds and the biological data, the selected sites were ranked according to the percentage of forest, pasture and bare soil, the population density and the number of industries and commercial facilities present. These attributes were mainly obtained from the analysis of human intervention performed by the Human Population component of the PMCC.

Table 2 shows the ranking of the sites according to the degree of human influence observed.

Table 2. Ranking of sites as per the degree of human influence.

Rank	Site
1	Río Agua Salud (dumpsite 2)
2	Río Limbo
3	Río Syristes
4	Río Casaya
5	Río Gatún (Pto. 1)
6	Río Frijolita/Mendoza
7	Río Frijoles
8	Río Aguas Claras
9	Río Agua Salud (dumpsite 3)
10	Qda. Aguas Claras
11	Río Gatuncillo (Pto. 1)
12	Qda. Sonadora
13	Río Cabuya
14	Qda. Sardinilla
15	Río Azote Caballo
16	Qda. Grande
17	Río Chilibrillo
18	Río Pescado
19	Qda. La Cabima (Pto 4)
20	Qda. Ancha (Gatuncillo)
21	Qda. Ñajú
22	Qda. Ancha (Chilibre)
23	Río Caño Quebrado

Index of Physical Intervention (IFI)

Definition

The Physical-Conservationist Diagnostic method was developed by the Inter-American Center for Development and Enviromental / Territorial Research (CIDIAT) - Mérida, Venezuela. In this method, several physical parameters of a watershed (or sub-watershed) are evaluated to estimate the critical value of the erosive factor, indicative of the physical condition. The Index of Physical Intervention may then be interpreted as a quantitative indicator of the environmental health of the watershed.

Objectives

- Estimate the value of the erosive factor in six main sub-watersheds in the eastern region of the Canal watershed with the purpose of determining the evolution of the level of physical degradation (Figure 5).
- Implement the method through GIS.

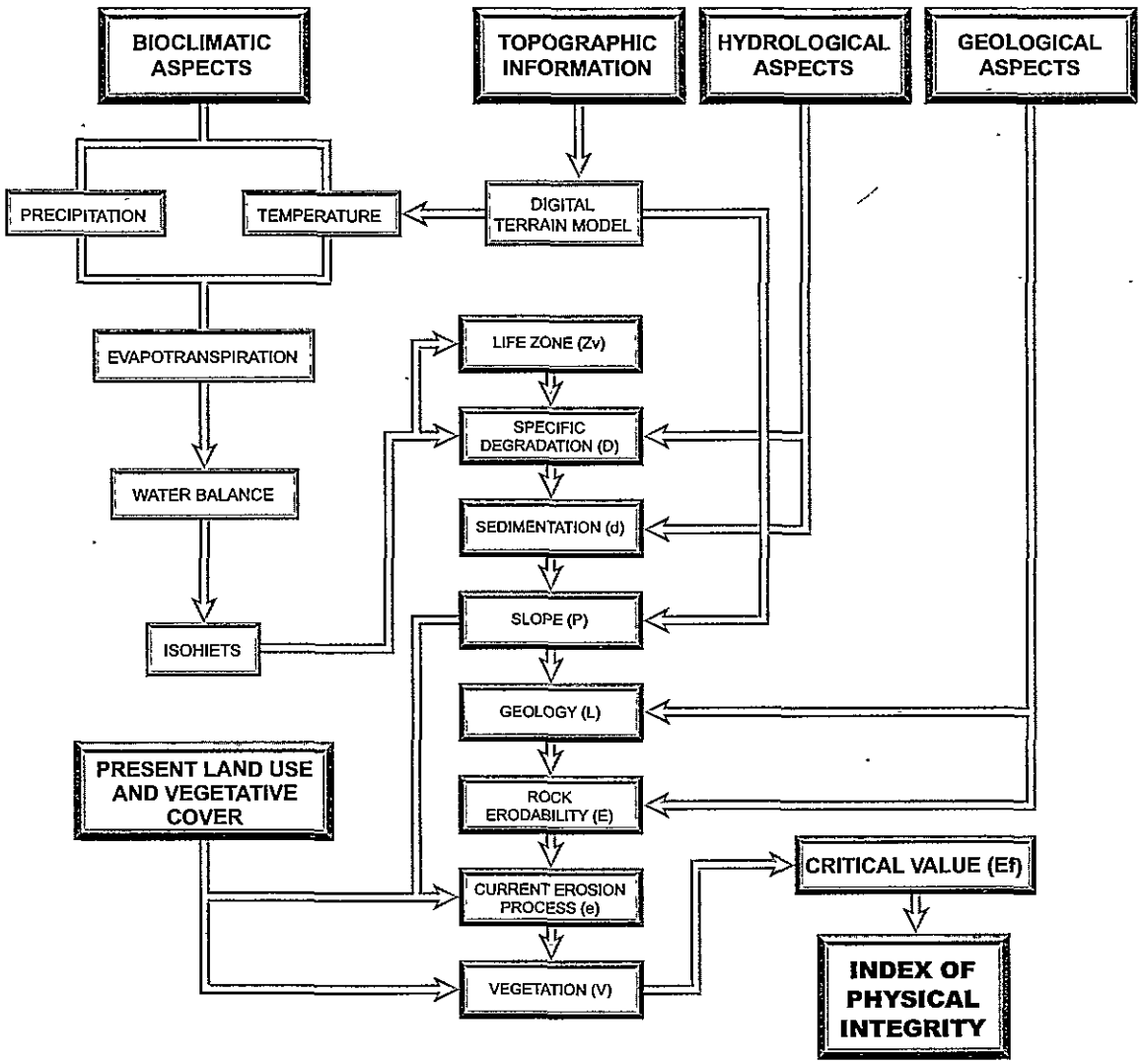
Methodology

The parameters that contribute to the Physical Conservationist Diagnostic are:

a) Value assigned to the current erosive process.
b) Life Zones.
c) Specific degradation (potential erosion).
d) Sediments measured at the gage stations (actual erosion).
e) Average slope of the sub-watershed.
f) Geology of the sub-watershed.
g) Rock erodability.
h) Extent of the current erosion.
i) Vegetative cover.

Of these, only factors ***a***, ***d***, ***h***, and ***i***, are variables subject to monitoring; the rest remain almost constant with time.

Figure 5. Components and functional relationships in the IFI.



This method has allowed for a quantitative analysis of the physical condition for each sub-watershed, establishing values from 12 to 32, respectively representing a watershed good condition or a degraded condition, based on erosion criteria.

Study Area

The Physical-Conservationist Diagnostic was performed on the six main sub-watersheds in the Alhajuela and Gatún lakes system: Río Chagres, Río Boquerón, Río Pequení, Río Gatún, all of these in the eastern part of the Canal Watershed, and the Ciri Grande and Trinidad rivers, located to the west.

All these watersheds have flow and sediment gage stations installed and operated by ACP at the outfall in the lakes (or proximate locations).

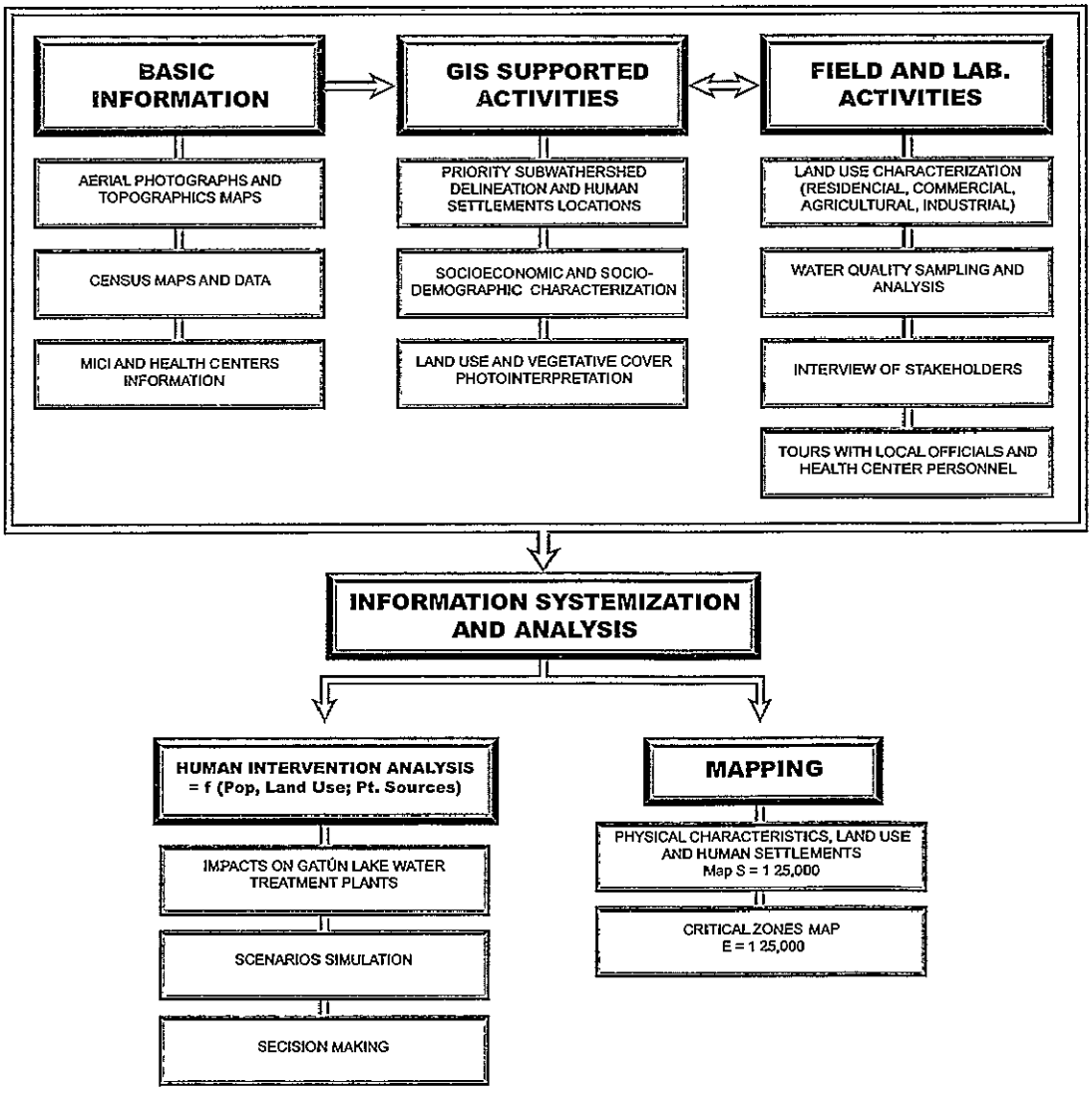
Anthropogenic Intervention Diagnostic

Definition

The Anthropogenic Intervention Diagnostic is a method developed by the Panama Canal Watershed Monitoring Program through which different effects of human intervention over water, vegetation, soil and human health are evaluated within a watershed. Figure 6 shows the method's characteristics.

The IAI is an indicator derived from the method that weighs and correlates the different parameters of the diagnostic, quantifying the effect of human intervention on the natural resources of a subwatershed.

Figure 6. Anthropogenic Intervention Diagnostic.


BASIC INFORMATION
GIS SUPPORTED ACTIVITIES
FIELD AND LAB. ACTIVITIES
AERIAL PHOTOGRAPHS AND TOPOGRAPHICS MAPS
CENSUS MAPS AND DATA
MICI AND HEALTH CENTERS INFORMATION
PRIORITY SUBWATHERSHED DELINEATION AND HUMAN SETTLEMENTS LOCATIONS
SOCIOECONOMIC AND SOCIO-DEMOGRAPHIC CHARACTERIZATION
LAND USE AND VEGETATIVE COVER PHOTOINTERPRETATION
LAND USE CHARACTERIZATION (RESIDENCIAL, COMMERCIAL, AGRICULTURAL, INDUSTRIAL)
WATER QUALITY SAMPLING AND ANALYSIS
INTERVIEW OF STAKEHOLDERS
TOURS WITH LOCAL OFFICIALS AND HEALTH CENTER PERSONNEL
INFORMATION SYSTEMIZATION AND ANALYSIS
HUMAN INTERVENTION ANALYSIS = f (Pop, Land Use; Pt. Sources)
IMPACTS ON GATÚN LAKE WATER TREATMENT PLANTS
SCENARIOS SIMULATION
SECISION MAKING
MAPPING
PHYSICAL CHARACTERISTICS, LAND USE AND HUMAN SETTLEMENTS Map S = 1 25,000
CRITICAL ZONES MAP E = 1 25,000

Objectives

- Study the impact of social groups and human settlements over the natural resources of the Canal Watershed, in order to identify areas with major deterioration and environmental pollution.

- Perform a human intervention analysis in the areas subject to highest human pressure, in which human activities (industries, agriculture and livestock, commerce, infrastructure, and settlements) can be monitored together with the natural resources and human health condition. Analyze, simulate and evaluate its evolution with reference to management practices and policies posed by the responsible institutions.

- Identify, design, develop, and implement a thematic database associated with a spatial component (GIS) of the anthropogenic activities, as a primary input for the CICH's Information System.

- Study and update the socio-demographic and socio-economic information of the population within the study area, identifying the most precarious communities and their dependence on natural resources.

- Identify the most critical environmental condition of deterioration areas to make possible the preparation of management plans and prioritization of the most urgent actions to undertake.

- Systematize the studies of land use, socio-demographic characterization, water quality and vegetative cover to adequate geographic scales, with a view of simulating diverse scenarios during long term planning.

Methodology

The analysis of human intervention is performed through the measurement of the following parameters:

- Population (population density, employment, morbility, income).
- Land Use (industrial, commercial, agriculture and livestock, mining, residential).
- Point sources of pollution (domestic and industrial).
- Vegetative cover (forest and scrub vegetation).
- Water quality (Biological Oxygen Demand BOD, Dissolved Oxygen OD, nitrites, nitrates, total and fecal coliforms).
- Physical characteristics (topography).

The geographical unit of analysis consists of the catchment area up to the water quality sampling points distributed along the main streams of the studied sub-watersheds. Information is collected by catchment area and integrated for the whole sub-watershed.

The methodology used involved different stages: office work (photo-interpretation, systemization of the demographic and socio-economic information by census population segments, etc.); field work consisted of cartography preparation, survey and interviews to stakeholders, water quality sampling, tours accompanied by health officials; systemization, analysis and mapping were performed with support from the GIS system.

Study Area

The following areas have been identified having the greatest pressure on natural resources:

- Transisthmian Corridor. The study area is comprised of the 11 sub-watersheds intersected by the Transístmica Highway. Six sub-watersheds discharge to the Río Chagres, upstream from the water intake in Gamboa (Chilibre, Chilibrillo, Cabima, Limón, Gatuncillo and Palenque in the corregimiento of Santa Rosa) and five discharge into the Gatún lake (Agua Sucia, Quebrada del Medio, Gatún, Aguas Claras and

Palenque in the corregimiento of Limón). All of them were classified as high priority by the Regional Plan, with the exception of Río Limón, classified as Very High Priority.

- National Park Areas. The largely populated sub-watersheds located in the margins of the Alhajuela lake were identified as areas of interest.

Analysis of results

Resulting from the process described, the following conclusions were obtained. These also generated and justified the proposed recommendations.

From the IBI analysis

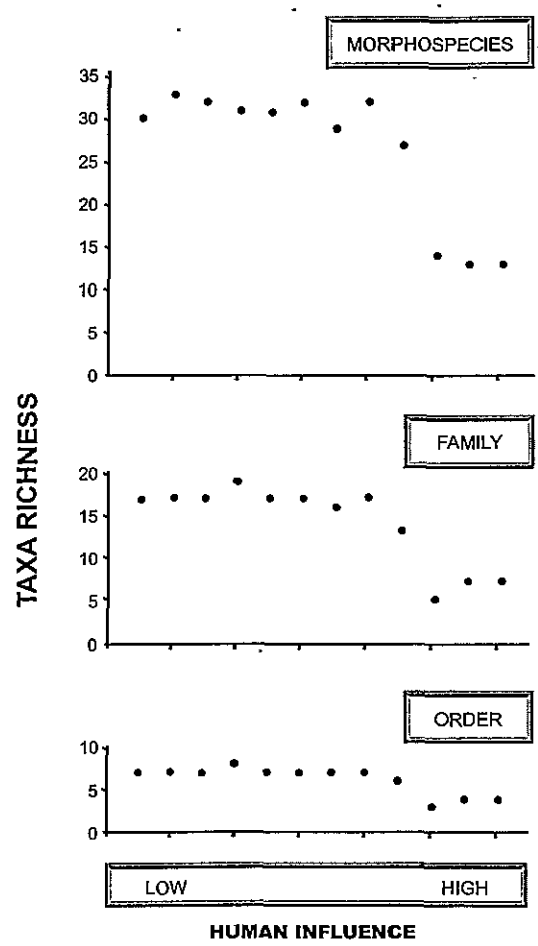
1. El use of aquatic insects in water quality monitoring, routinely done in other countries, is applicable to the conditions in the Canal Watershed.

   The plot in Figure 7 shows the results obtained at the Family and Species levels; they clearly show a functional dependence between the IBI metrics and human influence.

2. Amphibians are also considered indicators of environmental health. Nevertheless, very few studies have demonstrated that amphibians could signal qualitative changes due to human influence. The PMCC 2000 has developed a simple monitoring method that allows for the use of data on amphibian taxonomic richness and composition to compute multimetric indexes of biological integrity, which reflect the quality of both aquatic and terrestrial environments.

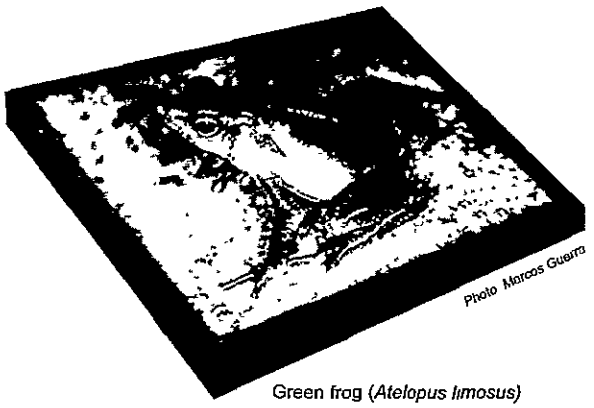
3. Amphibian populations show a declining trend worldwide, even in well conserved areas. Without a unique explanation for this decline, it has been suggested that amphibians are probably indicating environmental changes not yet perceived by humans. Similarly to the aquatic insects, the amphibian taxa richness diminishes as the human influence increases.

Figure 7. Average number of aquatic insects orders, families and species in studied micro-watersheds, as per the degree of human influence.



4. Ninety-three amphibian species have been registered in total in the Canal Watershed, 86 of which are frogs. This is a considerable number that represents 52% of the amphibian fauna in Panama, with a diversity peak in the Soberanía National Park.

5. Only 7 of the 93 species live exclusively in non-forest habitats (open areas); the rest of the species inhabit (or live) associated with the forests. Hence, amphibian protection is largely tied to the forest conservation and water quality in streams and shallow ponds.



Green frog (*Atelopus limosus*)

6. There are no unique amphibian species in the watershed; their habitats extend outside its limits. Nevertheless, two endemic species to Panama were found: *Atelopus limosus y A. zeteki.*

7. The total number of species per square meter found in each sampling site has varied widely over time, as has the abundance. Frog abundance is inversely related to the precipitation in the dry months. In general terms, the abundance has been low during 1997-2000. During the dry season in 1998-1999, a simultaneous and marked drop in the abundance of frogs occurred due to an exceptionally humid period; the abundance increased slightly during 1999-2000.

8. In spite of changes in abundance due to rainfall variability, frogs in the Canal Watershed do not seem to be suffering the drastic declines reported for Central America and other regions. Frog populations do not seem to have been affected by the disease that has caused massive mortality in the rest of the world.

9. The attributes identified as metrics for an IBI based on plants are: taxonomic diversity, abundance (of tree plants), tree dominance, canopy coverage, light and number of trees at the basal area level.

10. Plant diversity also shows a gradient related to human intervention.

11. If human intervention is selective and of low degree, the taxonomic diversity is higher because of the increase in small patches with different maturation levels.

12. Tree and shrub species frequency is greater in protected areas, while for small plants it is higher in partially altered areas.

13. The abundance of individuals of tree species diminishes with soil degradation.

14. Dominance is greater in degraded areas for both tree and small plants species. The same occurs with the scrub vegetation in recovered areas or cultivated plants areas.

15. For small plants, there is little taxonomic information, such that in many cases the species could not be determined.

From the Index of Physical Integrity analysis

1. The theoretical erosion values for the six studied sub-watersheds are within the range of 4,300 to 7,100 Ton/sq. km/year. These values are indicative of the soil loss potential if proper measures were not taken.

2. There is a direct relationship between the life zone index and the degradation results obtained by sub-watershed, indicating that this parameter is relevant to the protection of the watersheds. The elimination of the vegetative cover produces widespread changes in an area.

3. The level of current erosion estimated indicates that some watersheds have more than 40% of the surface affected by erosion to some degree, as in the Cirí Grande y Trinidad Rivers.

4. There is a marked difference between the theoretical erosion values and the sediment data recorded at the gage stations probably due to the fact that the not all the soil eroded from the watershed reaches the sampling points. Rather, sediments could be accumulating in small valleys and plains in the upper parts and fluvial terraces of the sub-watersheds.

   Table 3 summarizes the results obtained for the six sub-watersheds.

Table 3. Erosion index per sub-watershed.

Sub-watershed	Current Erosion Index E(f)
Cirí Grande	23
Trinidad	22
Gatún	20
Boquerón	18
Pequení	17
Chagres	16

5. Conducting baseline studies for the implementation of the Physical-Conservationist Diagnostic in the rest of the Canal Watershed would imply the installation of new flow gage stations and determination of sediment load. This is a possibility that ACP or ANAM could implement in the future (e. g. in the Western Region).

6. Sedimentation problems in the lakes have been controlled since long ago. Nevertheless, natural landslides in steep, barely covered soils occur and constitute one of the major threats in terms of siltation.

7. The hydrological information obtained in the Agua Salud Experimental Watershed will help calibrate hydrological models that could be adapted to other basins and significantly contribute to the understanding and assessment of the water resources in the region.

From the Human Influence analysis

1. It is possible, with the information obtained by the PMCC, to characterize the principal sub-watersheds in the eastern region of the Canal Watershed from the point of view of pollution levels. The information from the Human Population component was used as the basic input for a water quality model (QUALŻE) that can perform the following functions by river segment:

   - Characterize point and non-point sources of pollution and quantify contaminant loads.
   - Estimate the levels of various water quality indicators in each sub-watershed, including Dissolved Oxygen and Coliforms.
   - Compare the results with the quality standards for different potential water uses.
   - Determine the remaining assimilative capacity for each stream.
   - Simulate various scenarios of land use and industrial / commercial development.

2. Twenty five percent of the study area (41,300 hectares) is forested, with the forest areas concentrated in the headwater of the Gatún River in the Chagres National Park. The predominant land use in the downstream area of the park is pasture, occupying 20% of the total surface of the study region.

3. Approximately 10% of the area is occupied by human settlements; these are located along the Transístmica Highway and the numerous penetration roads that start at the highway.

4. The corridor region has an overall population of almost 40,000 people in more than 100 communities, according to year 2000 estimates. Commercial activities are mainly located in the Gatuncillo sub-watershed and include the largest industry within the Canal Watershed: the cement factory Cemento Panamá.

5. Thirty-three water-sampling points were identified along the main streams in the region. Water quality parameters analyzed included: temperature, pH, conductivity, total dissolved solids, turbidity and dissolved oxygen, with measurements taken on site with portable equipment; in the lab, fecal and total coliforms, BOD and nutrients were also analyzed. Sample collection was done once during the dry season and once during the rainy season.

As an example, the tables following summarize the characteristics of land use and water quality in the Gatuncillo River.

The results from the analysis indicate:

- The Dissolved Oxygen levels in almost all sub-watersheds are adequate to support aquatic life. Nevertheless, there are critical sites located in the Limón and Agua Sucia sub-watersheds, where the DO is below 5 mg/l, considered the minimum admissible.

- Regarding BOD levels, the most critical points are in the Gatuncillo and Limón sub-watersheds. In these cases, there is a direct relation between hog and poultry farms and poor water quality immediately downstream.

Table 4. Land use and vegetative cover in the Gatuncillo sub-watershed (areas in hectares).

Name	TCA*	Forest, shrub, scrub vegetation and reforestation	Pasture	Grass (Paja blanca)	Residential	Industrial	Mining	Commercial	Others	Total
Upper Gatuncillo (Pto 1)	615	351	117	0	0	0	0	0	148	615
Sardinilla (Pto.2)	1,232	290	191	0	0	0	0	0	136	617
Nvo Paraíso 1 (Pto 3)	4,172	911	970	0	0	0	0	0	1,058	2,940
Nvo Paraíso 2 (Pto 4)	4,783	238	165	0	0	0	0	0	208	611
El Valle de la Unión (Pto.5)	6,859	623	685	353	353	0	62	0	0	2,076
Nvo San Juan (Pto.6)	7,701	269	303	152	25	0	0	0	93	842
Desembocadura (Pto 7)	8,394	256	326	0	0	0	0	0	111	693
TOTAL	8,394	2,939	2,757	504	378	0	62	0	1,753	8,394

(*) TCA = Total Catchment Area

Table 5. Water quality parameters measured in the Gatuncillo River sub-watershed.

Parameters	Pt. 1	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Pt. 6	Pt.7
pH	8.36	8.03	7.96	8 19	7.90	8.12	8 01
Ce - Conductivity (mho)	154 5	135 6	159.0	166 2	216 0	221 0	229 0
T° - Temperature °C	25.9	25.5	26 2	26 6	26.3	26.7	25 7
S - Salinity (mg/l)	0 01	0 01	0 01	0.01	0 01	0.01	0.01
DO - Dissolved Oxygen (mg/l)	8 60	7 40	7 65	7.30	7 10	7 10	5.95
NO_2 - Nitrite (mg/l)	0.001	0 006	0.005	0.015	0.003	0 0012	0.011
NO_3 - Nitrate (mg/l)	0.7	0 6	0.7	0.8	0 4	0 5	0.5
NH_3 - Ammonia (mg/l)	0 010	0 020	0 000	0 040	0 020	0 012	0 060
PO_4 - Fosfate (mg/l)	0 100	0 100	0 090	0.120	0 110	0.130	0 090
Total Coliforms NMP 1/100	4,148	9,139	16,594	32,930	36,075	36,090	20,980
Fecal Coliforms NMP 1/100	233	399	394	610	925	1,5650	1,100
T - Turbidity NTU	2	4	10	10	14	13	26
TDS - Total Dissolved Solids (mg/l)	73	64	76	78	103	106	126
BOD (mg/l)*	N/a	N/a	1 0	N/a	4 0	N/a	N/a

(*) BOD - Biological Oxygen Demand N/a = No data available.

- Fecal coliforms, indicative of the presence of intestinal bacteria, are present in critical levels in all the Corridor's sub-watersheds. Values measured indicate that these waters are not suitable, without exception, for consumption or recreational activities. The most contaminated site in terms of fecal coliforms is in the Gatuncillo sub-watershed, where the count is 12,000 NMP/100 ml; a bathing site is coincident with this point.

6. The various land uses in the watershed, many of which produce nutrients from farms and settlements, provoke the growth (mostly at the discharge points) of aquatic vegetation, posing a threat to aquatic life and activities.

7. There is a very high level of reliance on surface water sources of potable water for all the population in the study area. Twenty-five aqueducts in the region and 6 direct water intakes supply approximately 16,500 people with water. In many cases, the lack of chlorine for water treatment is a recurrent problem. As a result of this, the health centers in the region show a very high rate of water-borne diseases, including diarrhea and skin affections.

8. It is not only water resources that suffer deterioration, but also forests and soils. For example, in the Filo de Santa Rita area, a reforestation project with teak has replaced natural forest in one of the areas with the highest biodiversity in the Canal Watershed. This reforestation project is on area susceptible to erosion, with steep slopes and heavy rain conditions, in which teak would not be recommendable.

9. Another contamination source, affecting air quality, is the Cemento Panamá cement plant. The frequency of respiratory diseases recorded by Policlínica San Juan is very high.

Recommendations

As per the Biological Integrity studies

1. A bi-annual monitoring program is recommended associated with this indicator. Sites sampled during year 2000 should be visited again in year 2002 and so forth. During the 2001-2002 period, sampling in additional sites could be performed; these would also be monitored every two years thus continuing the process. The additional sites should be selected depending on specific needs of information for the decision making process the degree of deterioration or environmental quality recovery. These sites could be located in existing urban areas or, in new settlements, to establish the baseline condition and provide future follow-up. Data obtained at these additional sites will improve the calibration of the biological response to human activities (gradient of intervention).

2. Prioritize the sub and micro watersheds of major interest regarding pollution condition.

Water sampling by PMCC personnel in the Agua Sucia River (Buena Vista).

3. Designate, among the technicians trained by the PMCC, those who would prepare the basic information for human intervention analysis, determining data gaps and needs in terms of GIS information.

4. Diffuse and discuss results at the inter-institutional level using the CICH as convoking and disseminating agent.

A per the Physical Integrity and Hydrological studies

1. Perform the IFI assessment once every five years, based on the fact it is linked to satellite image interpretation showing distinguishable changes in land use between periods.

2. Periodically update the other data used to prepare the IFI.

3. An important parameter in the physical integrity assessment is the Sediment Delivery Ratio, that is the sediment that actually reaches the river and is measured by the control stations; it is necessary to develop a methodology to simulate this process in watersheds without control stations.

4. Investigate the physical characteristics of soils to obtain a better understanding of the erosive process affecting these, as well as the conservation practices needed to protect them.

5. In order to reduce the areas affected by erosion, it is necessary to adequately protect and manage the vegetative cover, and regulate the production processes and agricultural and livestock practices, in a sustainable manner.

6. Relocate the Canal Watershed climate stations to correct existing deficiencies regarding their horizontal and vertical distribution as 20 out of 30 are located below 100 momsl and are concentrated in the surroundings of the Canal.

7. Extend the limits of the Altos de Campana National Park westwards, to include Cerro

Negro. This action would protect part of the headwaters of the Cirí Grande and Trinidad rivers, important tributaries of the Gatún lake.

8. It is recommendable to continue with data collection in the Agua Salud River experimental watershed, as the necessary equipment has already been installed. These data will help estimate the relationships of the hydrological response of a basin to the degree of human intervention.

As per the Human Intervention analysis

1. Every 10 years (coincident with the national census), socio-demographic and socio-economic studies should be performed at the corregimiento and sub-watershed levels. This would help update the social information and identify areas of population growth and loss as well as living conditions. These studies will be important to identify new pressure areas and re-orient the application of the IAI. To perform the analysis, it will be necessary to obtain aerial (preferably infrared) photographs.

2. Every 5 years, an update of environmental conservation projects and programs in the Canal Watershed should be performed, including those undertaken by communities, NGOs, government institutions and the private sector.

3. It is necessary to more strictly control the discharges of the poultry and hog facilities in the Canal Watershed as these are presumed to be responsible for most of the water pollution in the Transisthmian Corridor region. Control measures adopted should include monitoring of the discharges.

4. The association between health and water quality, in a surface highly dependent region on water like the Transisthmian Corridor, highlights the need for an urgent response to surface water pollution. Urban infrastructure such as waste collection, treatment and disposal systems, effluent treatment plants and emission control devices in industrial plants need to be implemented to mitigate the impacts of the main environmentally stressors.

5. Specific studies on water resources should be undertaken in the region that incorporate hydrological models as a startup for planning and management activities in sub-watersheds. Within this framework, is recommended an investigation on point sources from industrial and agricultural activities to determine their responsibility, and characterize the contaminant loads from non-point sources particularly livestock activities and human settlements.

6. It is important to delimit a buffer zone for the Filo de Santa Rita area and develop a management plan to protect it.

Family in Nuevo Ocu.

7. It is necessary to increase the riparian forest area along the Gatún and Aguas Claras rivers, to reduce the erosion caused by steep slopes and cattle raising in the riparian areas. The riparian forests would also contribute to the absorption of nutrients that otherwise would go into the streams.

8. In health matters, morbility records should be kept by "lugar poblado" (community) to establish a more detailed relationship between health and the environmental situation.

9. The inter-institutional coordination of the main government institutions and stakeholders need to be systemized and strengthened through the CICH.

10. Community awareness building and training programs on environmental health are needed to raise interest in community-based environmental monitoring (incorporating schools, NOGs and official institutions) to perform simple tasks, such as data gathering, to facilitate a better coverage and distribution of samples.

Synthesis

General Diagnostic

1. The ecological conditions in the Canal Watershed are such that they represent a great wealth of natural resources in good condition.

2. The flora represents a large share of the biodiversity in Panama, with 26% of the species.

3. Also the fauna, mainly birds, amphibians and reptiles, is representative of the natural wealth of the country.

4. As per the soil resources, soils with agricultural capacity are relatively scarce, with only 19% of the land area with soils classified in categories II, III, IV and V of the US Department of Agriculture (those categories recommended for agricultural or pasture activities). Most of the soils are most suitable for conservation and agroforestry according to their morphology and taxonomy.

Poultry farm in Nuevo Ocú.

5. Water, the most profitable natural wealth in the watershed and motor of the Canal activities, is abundant as a result of heavy precipitation and the water resources system developed to exploit it.

6. The Canal watershed lacks the environmental threats that devastate other regions such as hurricanes and seismic action.

Because of all these characteristics it may be considered a unique watershed in the world where sustainable exploitation could be combined with huge potential in terms of natural heritage profitability based on an integrated and consistent management.

Negative Aspects

1. Human intervention is a matter of concern: industrial development, lumber extraction, urbanization, commercial activities and mining are all present in the watershed to a certain scale. More than 150,000 people inhabit the region and their means of living represent, in a way or another, pressures on and threats to the environmental health of the watershed.

2. The eastern region of the watershed shows 48% vegetative cover remaining, the rest being used for extensive cattle ranching. The estimated annual deforestation rate between 1970 and 1998 is 1.5%.

3. In terms of pollution, conditions are not critical at the macro level: the water quality in lakes Gatún and Alhajuela is adequate to be processed in the treatment plants that supply drinking water to Panama City, Colón, La Chorrera and Arraiján; these lakes also support aquatic ecosystems of enormous variety. Nevertheless, worrisome threats come from pollution in critical areas, mainly along the Transisthmian Corridor. Pollution sources include raw sewage from human settlements, industries, dumpsites and agricultural/livestock activities. Some small watersheds show very high contamination rates in terms of organic load and coliforms. The exposure and usage of this water by the communities along the watercourses, is a matter of great concern.

Mitigation and protection measures

1. Authorities involved in the watershed protection, namely ACP and ANAM, have established since quite long ago institutional protection measures: protected areas creation, set up water quality standards, and solid waste management programs, among others. For these purposes, they have been supported by the multi- and bi-lateral funding agencies, among them USAID, Inter-American Development Bank, World Bank and Japan's International Cooperation Agency.

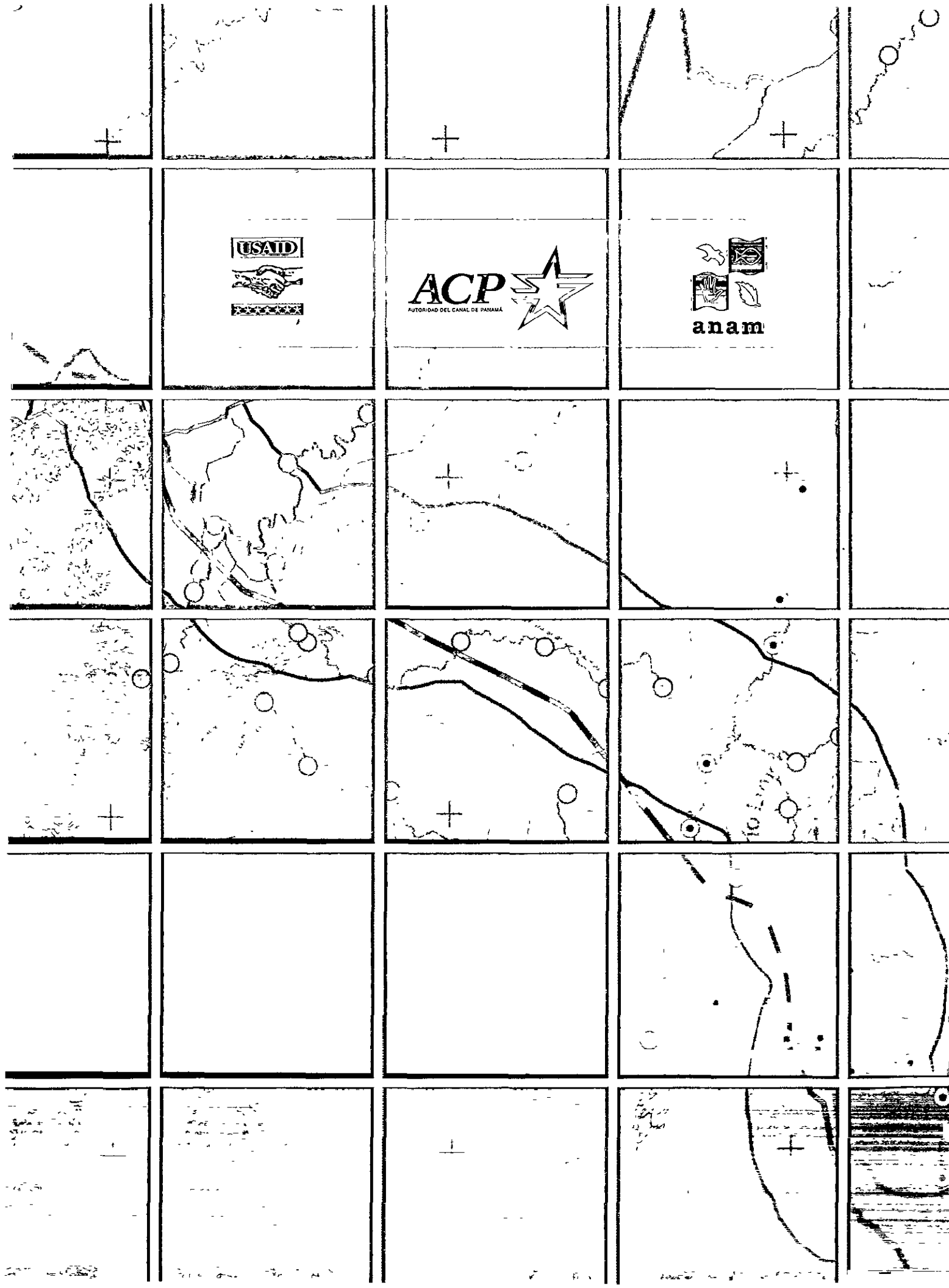
2. In the last five years, with the adoption of laws 21 (Plan Regional), 41 (ANAM) and 19 (ACP), an important step has been taken to establish the required legal and regulatory framework. Also, the recent creation of the Inter-institutional Canal Watershed Commission (CICH) represents a very important step in inter-institutional coordination.

3. There are management plans, at different stages of development, dedicated to control and mitigate the existing environmental threats. What is required immediately is that these plans are integrated to make efficient use of the available economic resources and promote consciousness on the importance of the community role in this context.

4. The watershed communities, most of them with an economic behavior that exerts pressure on natural resources, require incentives to develop environmentally friendly activities. Realistic ecological zoning, law enforcement capacity and environmental education are key elements in this sense.

5. A Monitoring Program is absolutely indispensable for the region's integrated management. Only through a clear perception of the daily actions that represent environmental threats, can Panama develop a synergetic effort to ensure sustainability in the Canal Watershed.

House in the Gatun lakeside.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